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An Empirical Test of the Environmental Kuznets Curve in Guangdong Province, China

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Abstract

This paper investigates the relationship between water pollution and economic growth in four cities of Guangdong Province in China based on the environmental Kuznets curve hypothesis, using urban data over 1990–2009. Waste water is used as the environmental indicator and per capita GDP is used as the economic indicator. Cubic function is used to formulate the relationship, with quadratic function and logarithmic function as comparison. The results show that the relationship between waste water and per capita GDP of Guangzhou city is inverse U-shaped, those of Shenzhen, Heyuan and Huizhou are not inverse U-shaped until 2009. Several reasons are listed for the phenomenon, among which the change of industrial structure is analyzed in detail.

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Keywords: Environment Kuznets Curve; Water Pollution; Economic Growth

1. Introduction

Many studies have explored the relationship between pollution and economic growth. The environmental Kuznets curve (EKC) is one hypothesis that has elicited wide attention (Arrow et al., 1995). The EKC concept was strongly put forward in the early 1990s by Grossman and Krueger (1991) as well as in the context of the 1992 World Development Report (Shafik and Bndyopadhyay, 1992). The finding of them is that there was an inverse U-shaped relationship between economic activity, usually measured in terms of per capita GDP, and the environmental impact indicator in some developed countries. That is to say, environmental degradation increases when per capita GDP is at a relatively low level, but that it

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will start to decline when per capita GDP reaches a certain point, the so-called turning point. Nowadays EKC has been one of the hotspots of environmental and resource economics. Selden and Song (1994) found that there exist an inverse U-shaped relationship between the per capita GDP and the discharged quantities of sulfur dioxide, suspended particulate matter and carbon monoxide. Pasche (2002) found that the trend of EKC is influenced by the technical progress and the industrial structure. Stern (2004) argued that developing countries are addressing environmental issues, sometimes adopting developed country standards with a short time lag and sometimes the environmental degradation will not appear. Fatma (2001) and Roldan (2001) argued that the cause of the inverse U-shaped relationship is that some developed countries transfer the pollution to developing countries by trade. Liu (2007) utilize environmental monitoring data from Shenzhen on concentration of pollutants in ambient air, main rivers, and near-shore waters from 1989 to 2003. The results show that production-induced pollutants support EKC while consumption-induced pollutants do not support it.

In this paper, we use statistic data of four cities in Guangdong province, China, to examine the existence of the EKC relationship between per capita gross domestic product (per capita GDP) and the waste water emission.

Nomenclature

W	waste water emission (in 100 million metric tons).
pGDP	per capita gross domestic product (in 10 thousand RMB yuan).

2. Data source

In our empirical analysis, we employ the data of four cities in Guangdong Province, China from 1990 to 2009 to test the EKC with per capita GDP as the economic indicator and waste water emission as environmental indicator. All data are available in the statistical yearbook of these cities.

Considering that the per capita GDP data included in the statistical yearbook are at current prices, they have to be converted into fixed prices. We adjust the per capita GDP by considering official price index (Consumer Price Index, setting year 2000=100).

For Guangzhou and Shenzhen, data from 1990 to 2009 have been collected. But for Heyuan and Huizhou, only data from 1996 to 2009 have been collected because of the change of the region division.

3. Model

In this paper, cubic function is used to formulate the relationship between waste water emission and per capita GDP, as is shown in formula (1) :

$$W = a \cdot pGDP^3 + b \cdot pGDP^2 + c \cdot pGDP + d \quad (1)$$

Quadratic function and logarithmic function are also used as comparison. They are shown as below:

$$W = e \cdot pGDP^2 + f \cdot pGDP + g \quad (2)$$

$$W = h \cdot \ln(pGDP) + i \quad (3)$$

The correlation index, R, is used to evaluate the fitness of the model and the statistic data.

4. Results and analysis

The results of cubic function are shown in figure 1, and the equations are formulated as below:

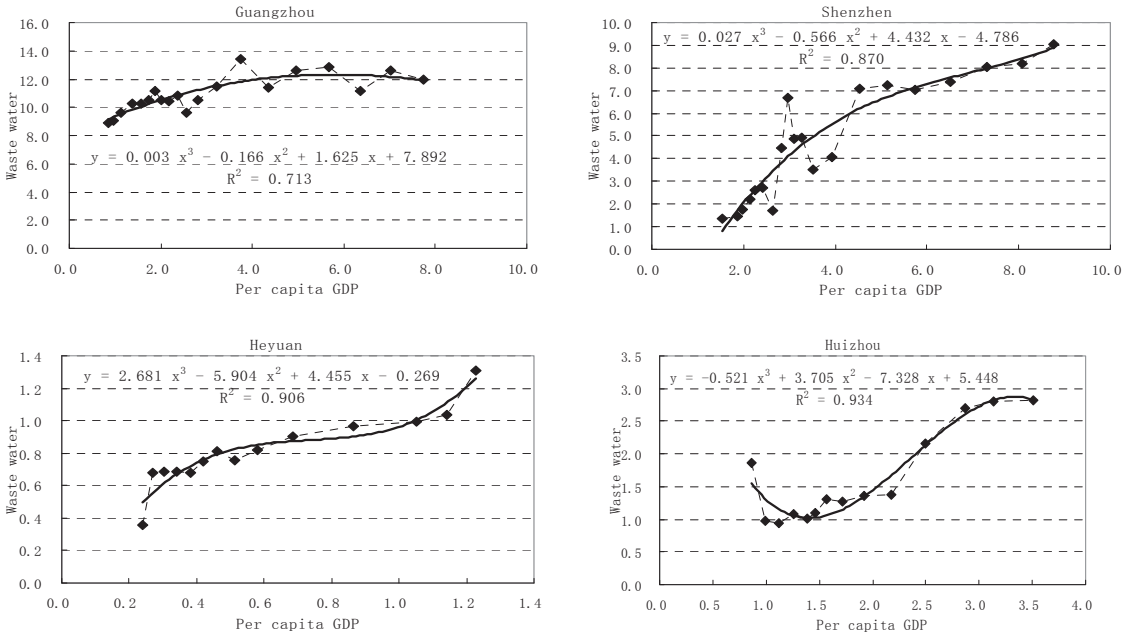

Fig. 1. The relationship between per capita GDP and waste water emission of the four cities shown as cubic function

For Guangzhou,

$$W = 0.003 \cdot pGDP^3 - 0.166 \cdot pGDP^2 + 1.625 \cdot pGDP + 7.892 \qquad R^2 = 0.713 \tag{4}$$

For Shenzhen,

$$W = 0.027 \cdot pGDP^3 - 0.566 \cdot pGDP^2 + 4.432 \cdot pGDP - 4.786 \qquad R^2 = 0.870 \tag{5}$$

For Heyuan,

$$W = 2.681 \cdot pGDP^3 - 5.904 \cdot pGDP^2 + 4.455 \cdot pGDP - 0.269 \qquad R^2 = 0.906 \tag{6}$$

For Huizhou,

$$W = -0.521 \cdot pGDP^3 + 3.705 \cdot pGDP^2 - 7.328 \cdot pGDP + 5.448 \qquad R^2 = 0.934 \tag{7}$$

Either quadratic function or logarithmic function, which has a larger value of R, is shown in Figure 2 and formula (8) to (11)

For Guangzhou,

$$W = -0.129 \cdot pGDP^2 + 1.499 \cdot pGDP + 8.006 \qquad R^2 = 0.712 \tag{8}$$

For Shenzhen,

$$W = 4.645 \cdot \ln(pGDP) - 1.052 \qquad R^2 = 0.865 \qquad (9)$$

For Heyuan,

$$W = 0.375 \cdot \ln(pGDP) + 1.057 \qquad R^2 = 0.851 \qquad (10)$$

For Huizhou,

$$W = 0.352 \cdot pGDP^2 - 0.775 \cdot pGDP + 1.604 \qquad R^2 = 0.831 \qquad (11)$$

From the results, the value of the coefficients can be seen. In formula (4), a≈0, b<0 and c>0 for Guangzhou indicate an inverted U-shaped curve. Because of a≈0, only little difference between the coefficients in formula (4) and (8) is shown. So it appears somewhat decrease of the waste water emission as the increase of the per capita GDP during the last few years for Guangzhou in both Figures. For Shenzhen and Heyuan, the monotonically increasing logarithmic function can also be used. It means that the turning points for them are not very near. A turning point perhaps will come for Huizhou, because its waste water emission of the last few years is kept at a near horizon. But the curve doesn't look like EKC.

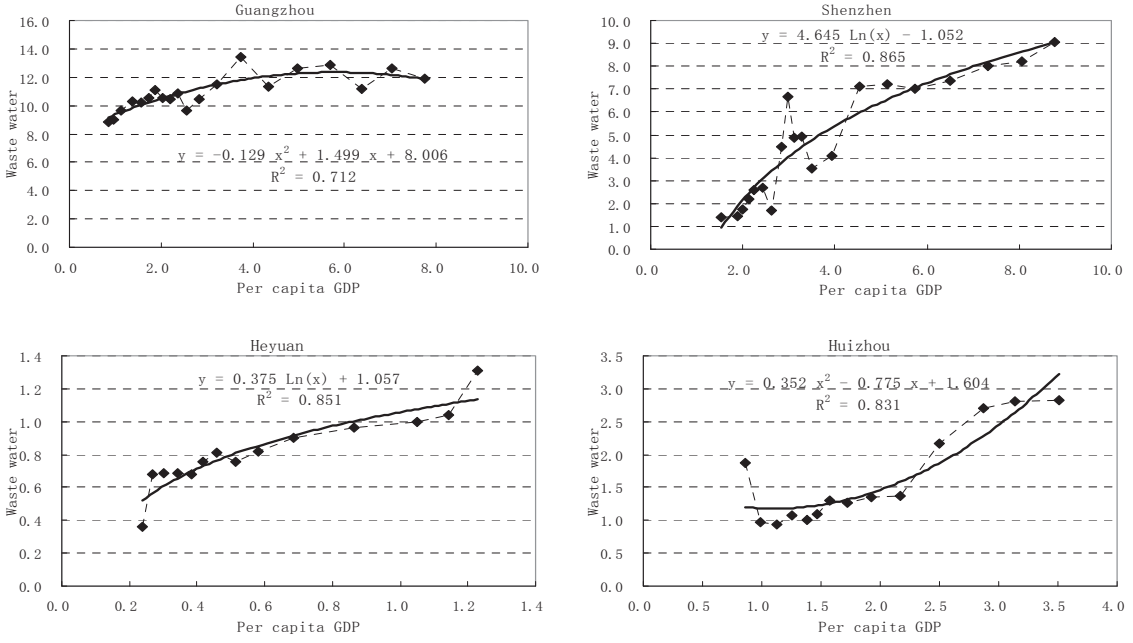

Fig. 2. The relationship between per capita GDP and waste water emissions of the four cities shown as other two functions

Several causes of this phenomenon are listed below.

First, there is an adjustment of industrial structure in the Pearl River Delta these years. Heavy pollution industries are limited and the proportions of the primary and secondary industry are reduced, with the increase of that of tertiary industry. The composition of GDP of the four cities divided by three industries is shown in Figure 3. We can see that the proportions of both primary and secondary industry of Guangzhou have been decreasing during the past about 20 years. Yet for other three cities this

phenomenon can not be seen apparently. For Shenzhen the sum of the two industries remains at nearly the same level. For Heyuan the percentage of primary industry kept decreasing, but that of secondary industry has been increasing during the near few years. For Huizhou the percentage of primary industry kept decreasing with that of secondary industry nearly unchanged.

Secondly, the environment of Heyuan is still good now, so people there maybe have not realized the threat of waste water emission. But the environment of Guangzhou is far worse than that of Heyuan now. So people there care more for the environment and are inclined to decrease waste water emission.

Third, a transfer of industries from cities in the Pearl River Delta, e.g. Guangzhou, to less developed cities, e.g. Heyuan, is ongoing. The heavy pollution industries maybe have transferred to Heyuan from Guangzhou.

5. Conclusion

This paper investigates the relationship between economic growth and environmental pollution in four cities in Guangdong Province based on the EKC hypothesis. Results show that there exists an inverse U-shaped relationship between the waste water emission and per capita GDP for Guangzhou. But the turning point of Guangzhou is just past. So attention should be kept on paying to decreasing the waste water emission. The relationship still can not be seen apparently for Shenzhen, Heyuan and Huizhou. The task of protecting the environment is still hard, and more money should be paid to decrease the waste water emission for the three cities.

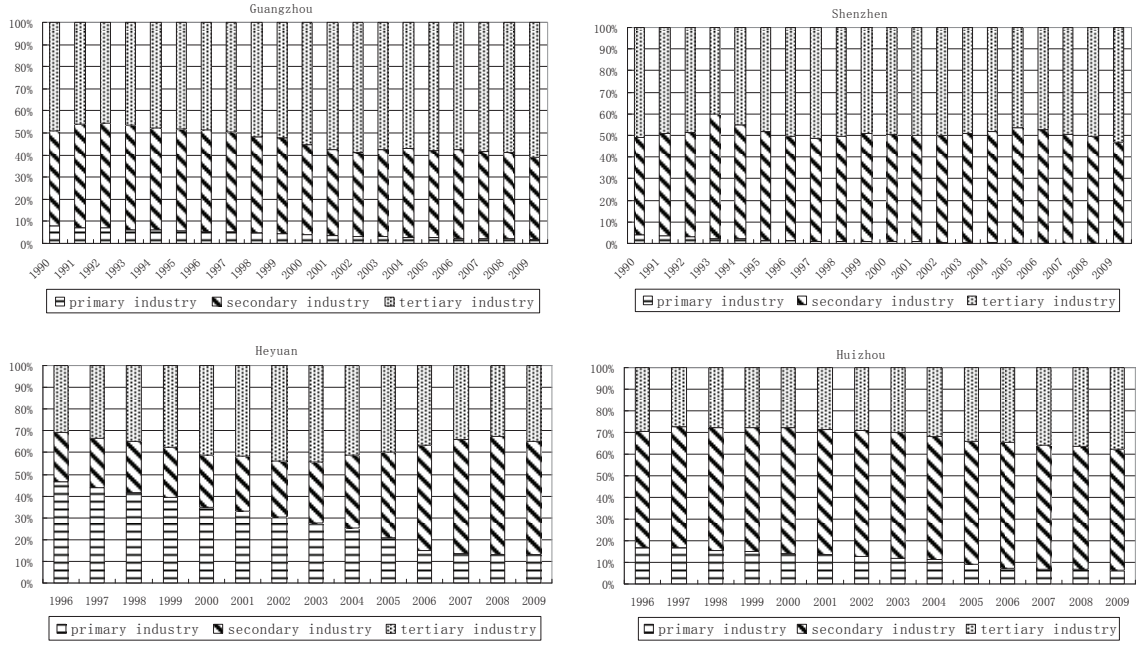

Fig. 3. The composition of Gross Domestic Product of the four cities divided by three industries

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